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Open-flap versus minimally invasive esthetic crown lengthening: Systematic review and meta-analysis

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ABSTRACT

Background: Esthetic crown lengthening is often performed to address excessive gingival display due to altered passive eruption. When bone reduction is required, most surgeons approach this procedure with an open flap approach. The aim of this systematic review and meta-analysis is to compare the outcomes of an open flap versus a more conservative closed flap approach.

Methods: An electronic search of Medline Pubmed and Cochrane library was conducted with "Does a flapless approach with piezoelectric to crown lengthening provide superior results than the traditional crown lengthening approach?" as the focused question. After reviewing the selected articles, the data was extracted to evaluate the relative gingival margin as the primary outcome variable. Statistical analysis was performed according to PRISMA guidelines for meta-analysis.

Results: Out of 65 studies, 4 prospective randomized controlled clinical trials met the inclusion criteria and were included for further analysis. The estimated standard difference in means for all studies was 0.349 (95% CI: (0.133, 0.565), $p = 0.002$) indicating that the open flap had a larger change in gingival margin from baseline to 3 months than the flapless technique. The results of Cochran's Q concluded no evidence of heterogeneity (Cochran's $Q = 4.745$, d.f.=5, p-value=0.448). The funnel plots and fail-safe analyses concluded no evidence of publication bias.

Conclusions: A minimally invasive closed flap approach using piezoelectric instruments, in the appropriate cases, seem to have better gingival margin stability at 3 months and excellent patient centered outcomes. Further well-designed studies are needed to shed more light on the validity of this technique.

Introduction

Altered passive eruption (APE) is diagnosed when there is an excessive gingival display with short clinical crowns. Esthetic crown lengthening (ECL) is the most common surgical treatment for altered passive eruption [1,2]. Based on the gingival and osseous relationships, the APE condition is classified into: Type 1 with a wider band of keratinized tissue and Type 2 with a smaller band of keratinized tissue measuring less than normal limits. Both types have subcategories, the A subgroup is defined as when the osseous crest is located 1.5 mm to 2 mm below the CEJ and the B subgroup is defined as when the osseous crest is found directly adjacent to the CEJ [3].

Traditional ECL involves osseous resection with gingivectomy to apically displace gingiva. The amount of soft and hard tissue removal in this technique aims to provide healthy and esthetically acceptable crown height by reestablishing biological width. However, gingival tissue coronal rebound is one of the most noted post-operative complications of this traditional technique [13]. On the other hand, the surgical techniques that include flap reflection may cause more coronal displacement of the gingival margin. Hence, it is crucial to assess different surgical techniques to determine the most effective technique that gives the desired and predictable outcomes with maximum patient satisfaction [4–6].

The osseous resection of ECL traditionally has been completed using hand or rotary instruments. Recently, piezoelectric has been a technique used for bone surgery with added benefits. Piezoelectric bone surgery delivers high precision in resection, good tactile sensibility, and permits a selective cut of mineralized tissue while sparing soft tissue [6]. These properties make piezoelectric technology suitable for osseous resection in ECL, especially in the closed technique. ECL traditionally requires full thickness flap reflection for access and bone removal. In addition, more time for flap reflection is necessary and surgical suturing, which may cause post-operative pain and bleeding. Hence, minimally inva-

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sive ECL technique (mECL) was suggested to reduce pain, post-op discomfort, procedure duration, and to accelerate the healing process. The mECL technique displays potential as an alternative approach to traditional ECL as a suture-less, atraumatic, and less invasive technique that has been shown to increase patient satisfaction and comfort. In addition, using piezoelectric for osseous resection in this closed approach increases the favorable surgical outcomes. However, the osseous resection in mECL may be incomplete and can result in coronal rebound on the gingival contour [16]. In addition, osseous resection in this approach is very technique sensitive to avoid root damage and uneven bone resection. A few studies and even fewer clinical trials evaluated the clinical outcome of mECL using piezoelectric for osseous resection (PZ). Hence, in this meta-analysis gingival margin and bone crest stability will be compared using the minimally invasive approach versus a traditional open flap approach (OF). In addition, a few of the papers included, will evaluate the use of a piezoelectric for osseous resection.

Methods

Focused Question: Following the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines a specific question was proposed [7]. The question is: "Does a flapless approach with piezoelectric to crown lengthening provide superior results than the traditional crown lengthening approach?"

Inclusion Criteria:

- Articles published in English.
- Patients who required crown lengthening surgery.
- Crown lengthening procedure that included a flapless technique.
- Flapless crown lengthening that required bone removal.
- Comparison to open flap crown lengthening surgery.
- Measured outcomes such as pocket depths, bleeding upon probing, clinical attachment loss, gingival margin and bone crest position, keratinized tissue width, post-operative pain and patient satisfaction.
- Prospective clinical trials.

Exclusion criteria:

- Any study that did not include comparison of a flap versus a flapless crown lengthening procedure.
- No measurement of gingival margin levels.
- At least a 3-month follow-up.
- *In vitro* studies, case series, clinical reports, animal studies, letters to the editor, expert opinion articles, abstracts, review papers, and unpublished articles.

Search Strategy: Electronic search of MEDLINE-PubMed and The Cochrane Library was conducted for articles addressing the focused question from 2009 to 2022. For the PubMed library a search methodology was performed using a combination of the following terms and keywords: ((crown lengthening) AND (flapless)). The authors (B.C., M.G. and A.E.) screened all titles and abstracts provided. Following initial review, if the information was relevant in the title or abstract, the paper was selected for full reading of the text. If the full-text papers fulfilled the eligibility criteria they were identified and included in the review. These papers were each reviewed again for relevance to the focused question and hand searching was also performed to ensure a thorough screening process and included the following journals: Journal of Clinical Periodontology, Journal of Periodontology, Journal of Periodontal Research and the International Journal of Periodontics and Restorative Dentistry. There were no disagreements among the authors concerning the final inclusion of articles.

Data Extraction: The information from each study was considered, such as: type of study, number of subjects, follow-up period, surgical technique, post-operative pain scores and clinical periodontal measurements. The data analyzed was based on the focused question. The primary outcome variable was the relative gingival margin.

Statistical analysis: All included studies provided mean gingival margin at baseline and 3 months for the open flap (control) group and the flapless (test) group. Random effects meta-analytic methods were used to combine the results of all included studies to determine an overall effect size estimate and the corresponding forest plot. This meta-analysis followed the PRISMA guidelines [8]. The mean difference in gingival margin was calculated as 3 months mean – baseline mean, and the standard deviation of the differences was calculated with the correlation assumed to be 0.5 since correlations and actual p-values were not provided in the studies. Between-study heterogeneity was assessed using Cochran's Q statistic and publication bias was assessed using funnel plots and fail-safe analyses. All calculations were carried out using Comprehensive Meta-analysis software version-3, (Biostat, Inc., Englewood, New Jersey, USA)

Results

From a total of 65 studies, 9 studies focused on a flapless approach to ECL. After exclusion criteria, 4 studies were included in the meta-analysis. The included studies were all prospective randomized controlled clinical trials. In addition, 3 of the 4 were split-mouth trials. The study conducted by Altayeb [10]. provided gingival margin results by tooth type (central incisors, lateral incisors, or canines) and these results were treated as three separate studies for the meta-analysis. The total sample size from all studies was 168 in the open flap group and 168 in the flapless group.

As shown on the forest plot (Fig. 1), the estimated standard difference in means for all studies was 0.349 (95% CI: (0.133, 0.565), $p = 0.002$) indicating that the open flap had a larger change in gingival margin from baseline to 3 months than the flapless technique. The results of Cochran's Q to assess between-study heterogeneity concluded no evidence of heterogeneity (Cochran's $Q = 4.745$, d.f.=5, p-value=0.448). The funnel plots and fail-safe analyses concluded no evidence of publication bias.

Discussion

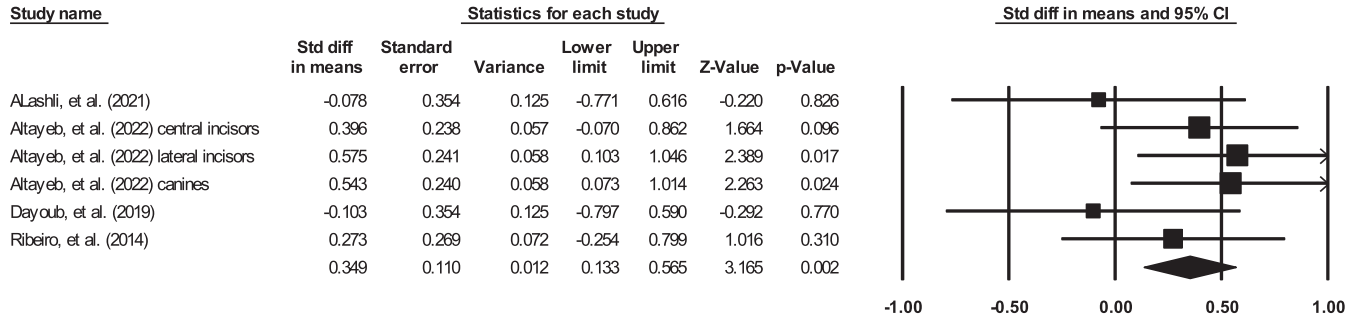
As far as we know this is the first meta-analysis comparing traditional ECL with flapless ECL. The results of the present meta-analysis slightly favored the use of a flapless approach to ECL. The results were compiled from 4 randomized controlled trials that met all inclusion criteria of this study. Statistical analysis showed the estimated standard difference in means for all studies to be 0.349 (95% CI: (0.133, 0.565), $p = 0.002$). This indicates statistically that the flapless approach had greater stability in the gingival margin after the surgery up to 3 months.

ECL surgery has been performed by dental professionals for years to help eliminate the appearance of a "gummy smile." These techniques most commonly refer to an open flap surgery with osteoplasty and ostectomy to re-establish the supracrestal tissue attachment. In today's world as techniques move towards a "minimally invasive" approach, the treatment for excessive gingival display (EGD) due to APE warrants a systematic analysis in evaluating the possibility of a flapless approach. After completing the literature search, multiple approaches to bone removal in both the traditional and flapless ECL are present. For instance, ALsahli and Dayoub used piezoelectric, Ribeiro used microchisels and Altayeb used a laser for bone removal [9–12]. However, piezoelectric bone surgery seems to provide a few advantages over a microchisel and laser. It has precision in bone resection, high tactile sensitivity, and a selective cut of bone tissue while not injuring the soft tissue.

The literature covering the flapless ECL technique is minimal with a total of 96 patients in only 4 clinical trials found meeting the inclusion criteria of the present meta-analysis. All 4 articles included are prospective randomized controlled trials with 3 being split mouth in design [9–12]. No case series, review articles, retrospective studies or clinical reports were included as these provide little scientific evidence. All articles had at least a 3-month follow-up with one study going up to 1 year.

Table 1
Data collection form.

Variable	Study 1	Study 2	Study 3	Study 4
Article title	*Assessment Of Two Techniques For Aesthetic Crown Lengthening (Flapless Piezo-Surgery And Open Flap Technique)* [9]	*Laser-Assisted Esthetic Crown Lengthening: Open-Flap Versus Flapless* [10]	*esthetic Crown Lengthening with Flapless Piezoelectric Surgery in Comparison with Traditional Open Flap Approach* [11]	*Open-flap* versus *flapless esthetic crown lengthening: 12-month clinical outcomes of a randomized controlled clinical trial* [12]
Article Authors	ALsahli, J., K. hossein Alhroob, and M. Alkhouli	Altayeb, W., et al.,	DAYOUB, S.T. and M.A. YOUSEF	Ribeiro, F.V., et al
Year of publication	2021	2022	2019	2014
Type of study design	Prospective, randomized controlled clinical trial with split mouth design	Prospective, randomized controlled clinical trial.	Prospective, randomized controlled clinical study with split mouth design	Prospective, randomized controlled clinical study with split mouth design
Country of study	Syria	Qatar	Syria	Brazil
Year of study	November 2019-December 2020	August 2014-March 2019	May 2018-November 2018	January 2011-July 2011
Groups Compared	Open flap control group and flapless test group. Both groups completed gingivectomies with blades. Both groups completed bone reduction with Piezo.	Open flap control group and flapless test group. Both groups completed gingivectomies and bone reduction with laser.	Open flap control group and flapless test group. Both groups completed gingivectomies with blades. Both groups completed bone reduction with Piezo.	Open flap control group and flapless test group. Both groups completed gingivectomies with blades. For the control group bone reduction was completed with surgical chisels. For the test group bone reduction was completed with surgical microchisels.
Primary Study Endpoints	Plaque index (PI), gingival index (GI), probing depth (PD), bleeding on probing (BoP), width of Keratinized tissue (wKT), relative clinical attachment level (rCAL), Relative bone level (RBL), Relative gingival margin (RGM). Measurements taken at baseline, immediate PO, 1-week PO and 3-month PO.	GML, SGT, tissue rebound, PI, GI, BOP, and PD at baseline, immediately PO, 1-month, 3-month and 9-month PO.	Plaque index, bleeding on probing, probing depth, relative CAL, relative bone level, relative gingival margin. Measurements taken at baseline, 1-week PO and 3-month PO.	PD, rGM, rCAL, KGH, and rBL were computed, separately, for interproximal and mid-buccal sites. The primary outcome variable was mean change in GM. Clinical measurement taken at baseline, immediately after surgery and 3-, 6-, and 12-months PO. Secondary outcomes included the additional clinical parameters of patient perceptions. Also, RANKL and OPG levels taken at baseline and 3-months PO.
Patient inclusion criteria and number included	Older than 20; bone thickness type: thin to moderate; patients with gingival smile due to APE 1B in at least 3 maxilla teeth per half contralateral quadrant; clinical attachment non-loss (N = 16 patients and 32 sites)	Excessive gingival display ≥ 3 mm; a gingival overlap of over 19% of the anatomical crown height; > 22 years old; having at least 20 teeth, with 6 maxillary anterior teeth indicated for ECL; full-mouth Plaque Index (PI) and bleeding on probing index (BOP) scores < 15%. (N = 36 patients)	Patients with a gummy smile due to APE (Type 1B) in at least 3 maxillary teeth per half contralateral quadrant; thin to moderate thickness bone pattern; >=20 years, no clinical attachment loss (N = 16 patients and 32 sites)	>21 years old; at least 20 teeth; no sites with attachment loss and probing depth (PD) >3 mm; and full-mouth plaque, bleeding on probing (BOP) and marginal bleeding (MB) index scores of <15%. (N = 28 patients and 56 sites)
Patient exclusion criteria and number excluded	Smokers and alcoholics; patients with systemic diseases that could interfere with healing; pregnant women and breastfeeding mothers; patients with protheses on treated tooth; patients with orthodontic appliance	Treatment sites with a probing depth (PD) ≥ 3 mm; cases where the restorative procedure changes the incisal edge in an apical direction; pregnancy and lactation; history of smoking; patients requiring antibiotics prior to dental procedures; previous mucogingival surgery; systemic conditions that could affect tissue healing; and undergoing active orthodontic therapy.	Pregnant or lactating mothers, smokers, use of an orthodontic appliance, any previous periodontal surgery in the same area, prostheses on treated teeth, taking antibiotics or anti-inflammatory therapies during last 2 months, or systemic health cases affecting the healing of tissues	Pregnancy; lactation; history of smoking; antimicrobial and anti-inflammatory therapies during the previous 2 months; previous mucogingival surgery at the region to be treated; systemic conditions that could affect tissue healing (e. g., diabetes); and use of orthodontic appliances.
Statistical analyses performed Odds ratio, 95% CI, p-value	Two samples t-tests and paired t-tests	Repeated measurers ANOVA, general linear model, two samples *t*-test, Mann-Whitney U tests	Two samples t-tests and paired t-tests	Two samples t-tests, Repeated measures ANOVA, Mann-Whitney U tests Mean reduction in GM after 3 months: OF 1.2 (0.5), FL 1.0 (0.5)
Study conclusions	Both techniques created a noticeable improvement in the length of clinical crowns compared to baseline (p00.05). Both therapies yielded an increase in the mean **rGM** (gingival margin) and **rCAL** (clinical attachment loss) with no statistical difference in amount of rCAL and rGM between both groups (P > 0.5). Results showed a noticeable improvement in the **pain** amount values in the test group (P < 0.05).	There was a significant difference in mean **GML** (gingival margin level) when compared to baseline for both groups (OF and FL) at 1, 3, and 9 months. There was a significant difference between the OF and FL groups for GML reduction at 1 and 3 months when compared to immediately after surgery (with the FL group showing more tissue rebound), however the difference disappeared at 9 months. Supracrestal gingival tissue (**SGT**) was significantly increased at nine months compared to immediately after surgery for all study participants in both groups (P < 0.001). However, no difference in between groups.	Both approaches created a significant increase in the length of clinical crowns compared to baseline (p00.05). Statistically lower means of pain, bleeding on probing, and surgical time were observed in the flapless group (p < 0.05). Both groups yielded an increase in **rGM** (gingival margin) and **rBL** (bone level) at 3months with no significant difference between the two. Based on a VAS, it was observed that the extent of **pain** experienced after surgery was statistically higher in the OF group compared with the FL group (p	Both therapies yielded an in- crease in the mean **rGM** (gingival margin) and **rCAL** (clinical attachment loss) at 3, 6, and 12 months (P < 0.05) compared with baseline. The mean rGM was higher in the OF group, compared with the FL group at 3 months (P < 0.05). No significant differences in terms of post-operative **pain** between both groups, however, there was a trend towards higher pain on the OF group. They found more interproximal BoP in the OF that they attribute to tissue trauma/healing due to papilla elevation and sutures. This also resulted in poorer esthetic results according to the author's in this OF group where scars were noticed.



Meta Analysis

Fig. 1. XXX.

Table 2
Data extraction table.

	Open Flap			Flapless		
Title	N	RGM Baseline	RGM 3 months	N	RGM baseline	RGM 3 months
Assessment Of Two Techniques For Aesthetic Crown Lengthening (Flapless Piezo-Surgery And Open Flap Technique)	16	2.85 (0.45)	4.10 (0.55)	16	2.79 (0.44)	4.08 (0.57)
Laser-Assisted Esthetic Crown Lengthening: Open-Flap Versus Flapless	36	7.81 (0.8)	9.97 (0.48)	36	8.0 (0.7)	9.9 (0.33)
Laser-Assisted Esthetic Crown Lengthening: Open-Flap Versus Flapless	36	7.18 (0.74)	9.06 (0.39)	36	7.44 (0.56)	8.99 (0.42)
Laser-Assisted Esthetic Crown Lengthening: Open-Flap Versus Flapless	36	8.13 (0.69)	10.35 (0.29)	36	8.36 (0.58)	10.28 (0.3)
esthetic Crown Lengthening with Flapless Piezoelectric Surgery in Comparison with Traditional Open Flap Approach	16	2.89 (0.48)	4.64 (0.61)	16	2.83 (0.48)	4.64 (0.67)
Open-flap versus *flapless esthetic crown lengthening: 12-month clinical outcomes of a randomized controlled clinical trial*	28	5.1 (1.1)	6.8 (1.1)	28	5.1 (1.1)	6.5 (1.1)

The articles were prospective in nature with patients randomly assigned into treatment groups, adding to the validity of the data presented. The primary outcome of the meta-analysis looked statistically at the stability of the gingival margin over time after surgery. The included articles recorded this finding using radiographic and clinical analysis. Two articles used CBCT to evaluate bone levels [10,11]. One article analyzed soft-tissue in addition to bone levels using soft-tissue cone beam computed tomography (CBCT) [12]. They explained their technique by having the individuals take a regular CBCT scan while wearing a plastic lip retractor in an inverted position and retracting their tongue toward the floor of the mouth. In addition to CBCT, clinical measurements were taken. To help the accuracy of the measurements, customized stents were also used [9–12]. While three of the studies clarified that procedures and clinical assessments were completed by one person throughout the study, others did not state the number of operators or examiners.

Important to note, there were additional results found in these studies that were not standardized and therefore could not be used in the statistics of the present meta-analysis. Three studies reported on post-operative pain and bleeding on probing and found higher values in open flap vs flapless groups. They attributed this to flap elevation, injury to the periosteal vascular supply and the use of sutures. Two of these three also evaluated the average time it took to complete a quadrant of ECL with a traditional vs flapless approach and found that with the flapless saved around 10 min. One of these three interestingly looked at levels of receptor activator of nuclear factor-kB ligand (RANKL) and osteoprotegerin (OPG) and compared concentrations between groups at baseline and 3-months. The findings were an increase in concentration of RANKL and OPG in the open flap group at 3-months compared to baseline with concentrations of OPG higher in the open flap group vs the flapless group at 3-months. These additional results presented in the 4 articles are important in providing evidence for the flapless technique.

As presented in the articles, case selection is of upmost importance. In order to provide the patient with a flapless approach to ECL, the patient must be a Type 1B patient with sufficient keratinized tissue outlined in the introduction of this review [3]. If the patient does not have sufficient keratinized tissue, a flap must be completed in order to apically position the tissue. It has been shown in the literature that keratinized tissue is important to maintain gingival health recommending a minimum of 2 mm of keratinized tissue with 1 mm of attached tissue around teeth to maintain gingival health [14,15]. Another selection criteria each article outlined is the thickness of buccal bone present. If the buccal bone is thick, then with a flapless approach, proper osteoplasty is not feasible due to access. In this case, instead of adequately reducing the supporting bone to reestablish a proper supracrestal attachment, ostectomy would result in a trough or bony defect on the facial. Therefore, in cases with thick buccal bone and/or minimal amounts of keratinized tissue, a flapless approach cannot be recommended. However, given the specific indications of this procedure, the minimally invasive surgical technique offers promising advantages to the traditional open flap approach. The studies showed reduced surgical time in the chair, amount of trauma caused by the surgery and faster healing with less post-operative pain for the patient. Further long-term and large sample size randomized controlled trials are needed to validify this technique.

Various case studies are found in the literature, but without a proper controlled study design, little can be taken from the articles. Although this minimally invasive approach holds potential advantages, further long-term studies need to evaluate the outcome and limitation of such an approach.

Conclusions

A flapless approach with piezoelectric to crown lengthening appears to provide superior results to a traditional crown lengthening in terms of reduced surgical time in the chair, amount of trauma caused by the surgery and faster healing with less post-operative pain for the patient all while maintaining stable gingival margins over a 12-month period (Tables 1 and 2).

Declaration of Competing Interest

Authors have no conflict of interest

Acknowledgments

The authors report no conflict of interest.

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